NAIC-ID(RS)T-0106-96

NATIONAL AIR INTELLIGENCE CENTER

SELECTED ARTICLES

NAIC-ID(RS)T-0106-96

HUMAN TRANSLATION

NAIC-ID(RS)T-0106-96 1 April 1996

MICROFICHE NR: 96C000292

SELECTED ARTICLES

English pages: 42

Source: Zhongguo Hangtian (Aerospace China), Nr. 177, January 1993; pp. 26; 41-46.

Country of origin: China
Translated by: Leo Kanner Associates
F33657-88-D-2188
Requester: NAIC/TASS/Capt Paul Woznick
Approved for public release: distribution unlimited.

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE NATIONAL AIR INTELLIGENCE CENTER.	PREPARED BY: TRANSLATION SERVICES NATIONAL AIR INTELLIGENCE CENTER WPAFB, OHIO

TABLE OF CONTENTS

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

ASIA-PACIFIC WORKSHOP ON MULTILATERAL COOPERATION IN SPACE TECHNOLOGY AND APPLICATIONS HELD IN BEIJING

Xiao Ping

ABSTRACT: The Asia-Pacific Workshop on Multilateral Cooperation in Space Technology and Application, co-sponsored by China, Pakistan and Thailand, was held on November 30 to December 5, 1992, in Beijing. It drew more than 130 participants from 23 countries and regions.

State Councillor and Minister of Foreign Affairs Qian Qichen addressed the opening ceremony. General Secretary Jiang Zemin met with all delegates attending the workshop.

Space collaboration, microgravity experiments, small satellite technology, remote sensing satellite technology/applications were on the workshop's agenda.

In developing their space industry, Asia-Pacific countries are grappling with low funding and limited technology and information. These problems should be solved through closer cooperation among the countries under the principles of mutual respect, equality and mutual benefit.

By thorough preparations, the Asia-Pacific Workshop on Multilateral Cooperation in Space Technology and Applications was first held in Beijing on November 30 to December 5, 1992. Over 100 senior officials, heads of space organizations, aerospace technology experts and specialists from 23 Asian and Pacific

countries and regions attended this gathering.

This meeting drew great attention and support from Chinese government leaders. State Councillor and Minister of Foreign Affairs Qian Qichen delivered the opening speech on behalf of the Chinese government. The General Secretary Jiang Zemin of China Central Party Committee also spent his time meeting with all participants.

During this workshop, representatives from different countries unanimously agreed that space activity is no longer only a luxury game played by a few developed countries. At present, nearly 60 countries throughout the world have competitively made investments in the development of space technology, and the research achievements of space technology have been applied in more than 100 countries.

Yet, in view of the developmental level and pace of space technology and its applications, the Asia-Pacific region lags far behind the developed countries. The major problems lie in the shortage of capital, technology, personnel as well as information in these countries. As a result, countries in this region ought to work together and help each other's needs by adopting the avenue of cooperation in the development of space technology and its applications so as to promote rapid social and economic development in this region.

Again at the meeting, the delegate from South Korea addressed the meeting with his country's experiences and efforts in training aerospace technical personnel, which left a deep impression on the participants. According to the delegate, South Korea spent over $10 million as technology transfer fees on the joint development and launch of the experimental KITSAT-1 satellite with Sali [transliteration] University, Britain. They are currently making preparations for the development of their

second satellite, the KITSAT-2. Aware of this fact, participants unanimously concluded that a space technology personnel training center should be established to train qualified aerospace technical personnel in this region.

The delegate from Pakistan where space telemetry has long been carried out, introduced his country's experiences in applications of remote sensing satellites, particularly the setting up of remote sensing ground stations and data imaging processing technique, which equally inspired the audience. Additionally, delegates from India, Thailand, Indonesia, etc, gave speeches explaining their respective space policies and concepts of upholding cooperation in space technology in the Asia-Pacific region.

Interestingly, the delegate from China as host of this meeting, gave an overall introduction to China's space technology development and applications, especially in areas such as the application of satellite technology to meteorology, disaster relief, telecommunications, and the like, which stirred keen interest among the participants. The Chinese delegation expressed their willingness to make greater contributions to multilateral cooperation in space technology and its applications in the Asia-Pacific region.

Once again, all participants agreed that an information center should be established first as a premise for cooperation in space technology, based on which, this region's technology exchange activity can be strengthened, and the limited information resources can be put into full use. Likewise, a liaison committee responsible for multilateral cooperation in space technology and its applications in the region should be formed in coordination with related activities. In addition, multilateral corporation in fields such as microgravity experiments, small satellite technology, and remote sensing

satellite technology and its applications were also brought up by the delegates.

The participants decided that the next meeting was to be held in Thailand, one of the countries proposing this meeting, late in 1993 or early 1994, for further discussion and examination over matters of cooperation and the forming of a permanent multilateral cooperation body.

APPLICATION OF SPACE TECHNOLOGY TO NAVIGATION

Wang Liru

ABSTRACT: A brief introduction to three main applications (telecommunications, navigation, and rescue) of space technology in sea transportation is given in this article.

Applications of space technology to navigation have not only revolutionized navigation, but also brought tremendous economic and social benefits. This paper outlines the applications of space technology to navigation, with the focus on its three widest and most beneficial aspects--maritime satellite telecommunications, satellite navigation, as well as the GPS system and the COSPAS SARSAT system.

Maritime Satellite Telecommunications

Since the launch of the first international maritime satellite, on February 19, 1976, old satellites have been continuously replaced by newer satellites. To date, there are still four international maritime satellites, respectively positioned in the following regions, namely, Atlantic Ocean east region (AOR-E) $18.5^{0\circ}$ W; Indian Ocean region (IOR) 66° E; Pacific Ocean region (POR) 180° E and Atlantic Ocean west region (AOR-W) 55.5° W, thus achieving a global coverage between south and north latitude 7^{0}o.

The International Maritime Satellite Organization (IMO) was officially established in June, 1976 and officially started to provide maritime satellite telecommunication services in February 1982, which include facsimile, telephone and data communications. By January, 1991, 12,874 ships (including 219 from China) have already been equipped with maritime satellite A-stations and 1737--with maritime satellite C-stations. With the realization of maritime satellite telecommunications, the backward intermittent telecommunication through high-frequency telegraphy and single-sideband cordless telephones was replaced by all-weather and high-quality telecommunications. The greatest contribution that maritime satellite telecommunications have made is that it has greatly improved human safety at sea and the rescue system, and thus brought enormous economic and social benefits. IMO statistics show that 1130 ships with an over 100 tonnage encounter sea accidents each year. To conduct timely and effective rescue operations for accident-stricken ships involves sending, receiving, and delivering SOS signals in time. With the implementation of maritime satellite telecommunications, the International Telecommunication Union (ITU) and Maritime Life and the Safety Treaty Organization (SOLAS) determined to carry out a thorough reform over sea distress telecommunications and work out a set of new regulations concerning the "Global Marine Distress Safety System" (GMDSS), scheduled to come into operation on February 1, 1992, and to be completely enforced on February 1, 1999, i.e., with seven years as a transitional period. By that time, the traditional Morse artificial telecommunication will eventually be replaced by a fully automatic, multifunctional all-weather telecommunications system. The implementation of GMDSS relies on the maritime satellite telecommunications system. For instance, in 1991, the oceangoing freighter Taoyuan chartered from China was hit by a typhoon while sailing in the Indian Ocean. The ship, with more than 80,000t ore on board, broke up and therefore was in great danger. Despite this, a satellite telecommunication shipborne station, installed on board the

vessel, kept continuous contact with home, and all the crew members eventually safely escaped from danger owing to timely and effective rescue operations. Another example is the oceangoing freighter Tonghai, which was stranded while entering port somewhere in Europe in 1991. Again, due to the all-weather operation of satellite telecommunications, the ship received timely and correct instructions from its company that read: "Pump out all ballast water and fresh water to float the ship" and then, after a few hours' effort, the ship was out of danger and avoided a possible shipwreck. In practice, the maritime transportation administration and policy-making staff well realized that it is worth spending $35,000 for a satellite telecommunication ship station and based on this knowledge, decided to speed up the development of telecommunication shipborne stations in China.

Maritime satellite telecommunications also play a major part in normal oceangoing telecommunication. In 1990, the Panama Canal was temporarily closed due to an American invasion, blocking that the channel that had been available for Chinese oceangoing freighters to sail to the east coast of the United States. However, our large-size container ships were all equipped with satellite telecommunication ship stations, which commanded and dispatched ship operation and as a result, not one ship had to anchor and await orders, ultimately minimizing the economic losses. We used to suffer from economic losses related to predetermined working shifts for lack of information about berthing and weather conditions. For example, in the United States, the 2.5 hours delay fee for two working shifts amounts to $7500 (equal to over 40,000RMB). But now, since satellite phones can reach any department or company with telephone lines, ships can be informed in a timely manner of berthing from deckside, and can properly regulate speed so as to save fuel, and more importantly, the economic losses caused by unnecessary waiting, anchoring or delays can be avoided.

In addition, satellite telecommunication stations can play a special part under unusual conditions. One example in this respect is the accident that happened to a ship, the Chaohe, which took place in the United States 3 years ago. Shortly after the accident, detailed data on the location of the accident were required by the American Maritime Court. If the information failed to be offered, the case was expected to lose. Fortunately, the representative from Chinese side made a timely contact with the ship's crew to obtain the required information. As a result, the case was won by the Chinese side, ending up with $1.2 million in compensation for the economic losses from the losing side.

Among other matters, in daily correspondence among ships at sea, the likelihood of common information exchange turns to be possible thanks to satellite telecommunication. For instance, the machinery damage machine status, blueprints, seamen identification, as well as ship belongings, and food requisition list, and so on, all can be quickly transmitted to the management by facsimile. Shipowner companies, on the other hand, can send their emergency documentation and instruction in a timely fashion to vessels, enabling a timely reception of information from home by those vessels that have been away from home for a long time.

Satellite Navigation and GPS System

The development of navigation technology, in one way, relies on the development of aerospace technology. One example from 1964 illustrates this: the 10,000-ton Chinese vessel Yuejing sank because it ran onto rocks during its maiden voyage to Japan. The cause of this misfortune is that it lost its bearings and had to blindly continue its voyage. Yet, with the development of science and technology, the advanced positioning apparatus has been made possible for human use.

For centuries, many navigation systems have been developed, from LaolanA, LaolanC, Omega, up to the Meridian satellite navigation system invented in the late sixties and early seventies of this century, and positioning accuracy has been increasingly improved. Typically, positioning conducted by this system is achieved through using six satellites circling the earth and sending accurate location information every 2h. However, the location error can be as high as over 100m, not to mention intermittent positioning, which sometimes leads to over 10h of dislocation.

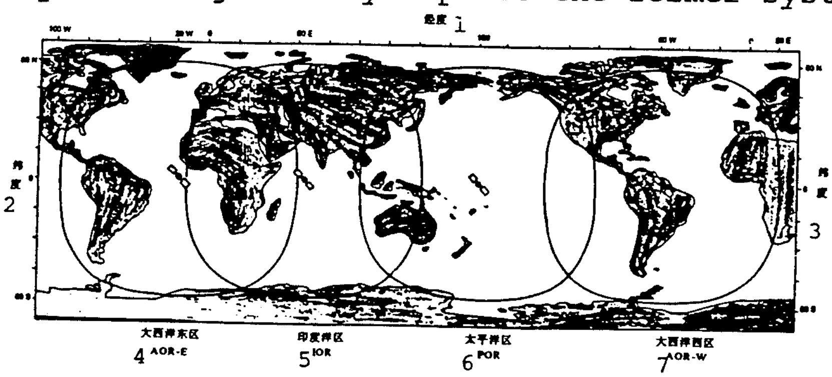
Aware of the defects existing in Meridian satellite navigation system, the United States government decided to develop a global positioning system (hereinafter referred to as GPS). This system includes a spaceborne system and ground control system with the deployment of 24 satellites in space 20,000km from earth, distributed along six orbital planes with each orbital plane holding four satellites, of which, 21 satellites are for normal operation while the remaining 3 are backups. Their travel orbits are sub-synchronous (travel time is 11h 58min each week). So far, 18 satellites have been brought into use, and it is estimated that by the end of 1993, the overall setup will have been completed and can be fully put into use.

GPS, among other things, can provide two-dimensional (longitude and latitude) and three-dimensional positioning (longitude, latitude and height), which can be used not only by vessels at sea, but also by aircraft in flight. GPS enjoys its high accuracy in positioning and its P yard accuracy, in military affairs, can come to several meters; while the C/A yard for civilian use can, without the S/A policy (artificially lowering positional accuracy), can be as much as 15m under the condition that horizonal geometric accuracy is less than or equivalent to 3. Also, the positional update rate can be once every second,

fully meeting the needs of navigation. The application of the GPS system is undoubtedly a phenomenal revolution in navigation equipment.

With the fast progress being made in aerospace technology, the latest information (satellite calendar) can be sent to satellites through a ground system at any time and any place to make vessel receiving equipment comparatively simple. Subsequently, GPS has well been received in the navigation community as soon as it came into being, and its applications have spread at amazing speeds.

The Chinese oceangoing industry made a decision to stop ordering the Meridian navigation system and instead, decided to use the GPS system to gradually replace the former system.

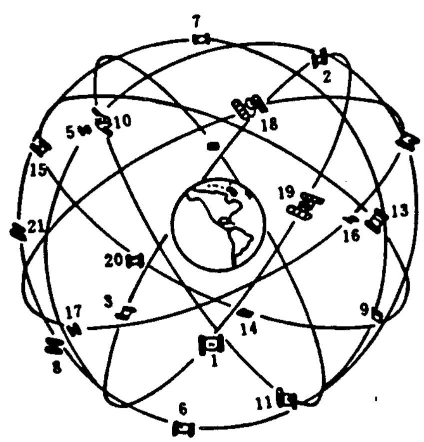


Coverage Map between South and North Latitude 70° by Maritime Satellites
KEY: 1) Longitude 2) Latitude 3) Latitude
4) Atlantic Ocean East Region 5) Indian Ocean Region
6) Pacific Ocean Region 7) Atlantic Ocean West Region

The GPS receiver is not only used as a navigation instrument for high accuracy and continuous positioning, but also possesses the capability of performing a speed measurement (error is limited within 0.1 nautical mile). Virtually speaking, it can also display course when the vessel travels at uniform even speeds. Therefore, it is a new type of equipment used for three purposes (positioning device, log device, and electrical

sextant). Still it is characterized by various functions including navigation, timing, time reporting, and navigation computations.

Again, the popularization of the GPS system will tremendously change the image of oceangoing safety and provide technical assurance for comprehensive navigation (called single-pilot stand in foreign countries). As a result, the crew on board can be reduced, pilot workload can be eased, and pilot mental outlook can be improved. Further, the unsafe factors occurring in the past, including mistakenly entering restricted areas, fishing areas, travelling on wrong courses, misidentifying buoys as well as losing bearings--all these can be eliminated with the application of GPS. As far as the navigation department is concerned, safety plays a decisive role in regards to various indices. Obviously, GPS system brings navigation significant social and economic interests.



Coverage Map of GPS

COSPAS SARSAT System

In the eighties, several serious accidents affected Chinese navigation practice, as follows:

In 1982, the freighter Daqing 53 suddenly exploded claiming

a dozen lives. In July 1982, the freighter Xijiang capsized and sank due to cargo movement. In November 1983, the freighter Zhangdou 67 capsized overturned and sank under high winds, claiming more than 20 lives. In June 1986, the new vessel Debao, built by Romania for China sank in the India Ocean because of high winds, taking 32 lives.

The foregoing tragic sea accidents indicate that these accidents occurred in an instant, which made the vessels fail to send a SOS signal, and therefore the ship company could not provide a timely rescue. Hence the casualties caused by these accidents were enormous. How this misfortune can be avoided becomes a question. And COPAS SARSAT is the solution, which, by using its satellite, can send SOS messages to rescue departments.

COSPAS is an abbreviation of Cyrillic letters standing for former Soviet Union satellite Cosmos. SARSAT is an abbreviation of English letters representing the geographic satellite of the U.S. National Oceanic and Oceanographic Administration. COSPAS SARSAT has a total of four satellites, which were initially developed jointly by the United States, the former Soviet Union, Canada, and France in 1979, and placed in use in 1985. This system was designated as the international satellite searching and rescue system on July 1, 1988. The U.S. geographic satellite uses search frequencies 121.5MHz and 406MHz, of which, the former was used mainly for aviation while the latter, for navigation.

The former Soviet Union's Cosmos satellite and the U.S. geographic satellite respectively move in space 1000km and 850km from earth and circle the earth at 7km/s, with about 100min per revolution. Each satellite covers 4000km^2 of the earth. From the view of any point on earth, roughly every 10-15min that point is overflown by a satellite. Therefore, when the SOS signal is sent from any point on the earth, it can be searched by the

satellite in 15 minutes at most, and immediately transmitted to a ground station.

The COSPAS SARSAT rescue system, apart from satellites, has a ground rescue network, various emergency location indicators (including a satellite emergency location indicator for vessels at sea, an emergency location sender for aircraft as well as land action satellite location indicators for land).

All the foregoing emergency location indicators can operate on the frequencies 121.5MHz or 406MHz. They have automatic transmission capability. For instance, if a vessel is about to sink at once, the emergency satellite location indicator can be turned on manually to send out an emergency signal. If it is too late to operate it manually, this device can be automatically turned on and send the emergency signal after the vessel has sunk 2m under water, which can then avoid tragedies due to failure to send emergency signals in a timely fashion. When COSPAS SARSAT receives the emergency signal, it will immediately deliver location and ship data to the rescue center so that a timely rescue will be available.

The probability of COSPAS SARSAT detected an emitted emergency signal sent is better than 98% and the probability of point location is 90%. The positioning accuracy for signals received on 121.5MHz frequency is 17.2km and for signals received on 406MHz, it is about 5km. Therefore, it is absolutely certain that this system is capable of providing a reliable information delivery system for sea accident rescue operations.

For 6y since the application of COSPAS SARSAT rescue system, 437 accidents have been successfully discovered, saving as many as 1150 lives (including 510 people rescued at sea, 590 people rescued after air crashes, and 50 people rescued on land)in the air, and 50 on the ground), achieving remarkable social and

economic benefits.

Summary

Since the implementation of the foregoing three space technology applications, the navigation industry has been considerably improved and developed. The social and economic benefits they have brought are immeasurable. Meanwhile, the "Maritime Life and Safety Treaty" has been correspondingly revised by the International Maritime Organization to enforce a the compulsory use of the foregoing technologies. Additionally, the new regulation providing for the application of the GMDSS system was officially implemented on February 1 of this year; and the vessel emergency location indicator of the COSPAS SARSAT system is scheduled to be put in place on August 1, 1993 and thousands of GPS receivers have been used by customers.

In addition to the foregoing several aerospace technologies directly applied to navigation, aerospace technologies for indirect use of navigation devices include facsimile receivers for satellite cloud atlases, disaster weather forecasts, satellite television relays and reception, all closely related to the development of navigation industry as well.

COMMERCIAL PROSPECTS FOR SATELLITE REMOTE SENSING

He Xin

Satellite remote sensing is a fast-growing new discipline, which has played a more and more important role in human productive activities and will become the second aerospace industry following the satellite telecommunications industry. Presently, some countries in the world have their own remote sensing satellites, including the United States, Russia, European Space Agency Bureau, Japan, China and India, followed by countries such as Canada, which is planning to launch remote sensing satellite as well.

To date, the two largest satellite remote sensing information companies in the world are the Earth Observation Satellite Company in the United States (hereinafter referred to as EOSAT), selling LANDSAT satellite data, and the French SPOT Company. In fact, there are as many as 200 companies dealing with remote sensing that have registered with the U.S. Department of Commerce. Additionally, over 150 business entities, academic institutes as well as government organizations have utilized EOSAT products.

Business in EOSAT is growing rapidly, with yearly profits reaching as high as $100 million, showing a 20%-30% growth rate. In 1991 alone, the total sales of LANDSAT data was $32 million, while the annual revenue from SPOT totaled $40 million.

The reason why remote sensing technology so quickly took hold in the marketplace is attributed to the development of low-cost, high-speed and large-volume computers and the development of digital imaging technology. Thus far, the majority of remote sensing images have been sold as computer tapes. The EOSAT, though, is beginning to sell data recorded on 8mm diskettes. Of a total of the images sold from the EOSAT, only less than 20% were sold as films or pictures, among which, one LANDSAT panoramic TM image with a coverage of 185km by 170km was valued at $2700, and one digital image cost $4400, while one SPOT panoramic digital image or picture with a coverage of 60km by 60km sells for $2450 to $3000.

Among other matters, two factors have drawn great interest to satellite technology, namely (1) remote sensing data have been applied in local and global environmental observations; and (2) satellite remote sensing data were used by the multinational forces in the Gulf War. Currently, the U.S. Air Force is still the biggest patronage of both EOSAT and SPOT.

At present, the Geographical Information System (hereinafter referred to as GIS) shows a great potential in the remote sensing marketplace. This system was originally developed by the ERDAS Company in the United States in 1978 with a GIS prototype built at Harvard University that not only reduced the size of the device, but also lowered the price from $1 million to $50,000. The GIS system now has been sold to over 70 countries. It is estimated, according to the head of this company, that GIS will come to occupy a place in the nineties similar to office automation and electronic instruments in the eighties.

GIS is playing an increasing role in remote sensing advances. Along with its capability in analyzing and processing a variety of geographical data, it also allows for data such as vital statistics, natural resources, various economic activities

and disaster distribution to be stored in the system. And these stored data can be retrieved from a workstation or a personal computer, which helps solve the problem of complex data management and other technical problems.

It is estimated that GIS has become a large lucrative industry with a market of $5.3 billion, of which data acquisition amounts to 65%-75% of total output value. So far, the annual sales of GIS system hardware and software, as well as data, has topped $5 billion. Even though the annual sales of most GIS companies are less than $5 million, the GIS system used by the blue chip corporations such as IBM, IT&T, and the ESRI Company all have annual sales ranging from $30 million to $280 million. A study shows that within next 5 years, the sales of GIS data will grow by 17% each year.

The application examples of GIS remote sensing data can been seen as follows:

1) In 1992, the commercial district in Chicago city was hit by sudden floods and turned to the SPOT Imaging Company in requests for the latest disaster-stricken area satellite image. In response to the demand, SPOT Company took timely action by offering the image within 48 hours. In this case, speed is more important than price. Without the satellite image, the only related tool that disaster rescue team could have access to was a confused line drawings depicting numerous pipelines, tunnels, streets, and buildings.

2) The LANDSAT data provided by the U.S. Forest Service with a GIS system can be used to determine the favorable location for planting special trees containing a medicinal agent to cure cancer.

3) In the island of Tarawa, where the cultivated land has been shrinking at a rate of 6000acres annually, color imagery

data with a resolution of 10m provided by SPOT are used to conduct land observations. By comparison, if the observations are done through aerial photography, the land with an area of 5.20 million square kilometers would require spending $40,000, while with data from SPOT, the cost is only $5,200, and with better coverage.

4) In Singapore, LANDSAT surveying data provided with the GIS system are used for urban planning specially to deal with heat island effect since a population of 2.6 million occupy a land of only 6.2 million square kilometers.

5) Multispectrum satellite data are used by farmers in the United States to observe crop growth and to help select optimal irrigation times. In addition, this aerospace technology will play a vital part in future of American agribusiness.

6) At present, some remote sensing customers are positioning themselves as GIS manufacturers. It is known that fast-food business such as Macdonald's is also planning to sell GIS software that can be used to choose new business locations in fast-developing economic zones.

Detecting geographic variations is GIS's main concern. For instance, newly updated maps are one of SPOT's best-selling products. In early July 1992, the IBM Corporation signed an agreement with SPOT to sell satellite images for SPOT. Many persons in the field of commercial remote sensing believe that IBM's involvement in GIS software market is highly significant. As a result, IBM will grow to be a major manufacturer in GIS hardware production and assembly.

TWO EXAMPLES OF AEROSPACE TECHNOLOGY APPLICATIONS (7)
Lightning Prevention and Protective Techniques

At present, more and more composite materials have been applied in aircraft design to reduce weight and increase strength. Similarly, to enhance the efficiency of flight and engine control, digital electronic systems have been used in aircraft. However, use of these two techniques somehow causes aircraft to easily incur lightning damage.

To solve this problem, a seven-year lightning investigation was conducted at the NASA Langley Research Center as an effort to determine the damage that thunderstorms may bring to commercial flights. This program focused on using an F-16B aircraft equipped with a special device and an anti-lightning system to record more than 80 lightning strikes encountered during its flight across lightning areas.

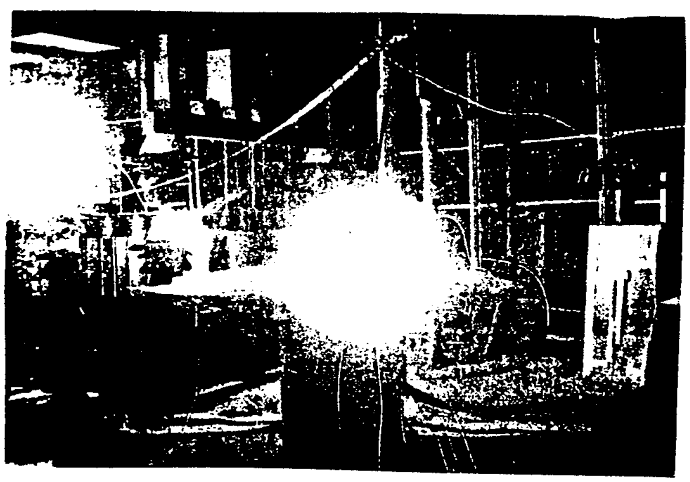
The research on lightning at the Langley Research Center shows that when encountering lightning, the aircraft incurred powerful stray electric currents, which might cause the magnetic field to change, and result in interference to the sophisticated electronic systems on board. Again it was found through the research that the place most like to be struck by lightning may be located in the protruding parts of an aircraft including wings, propeller tips, or anywhere on the aircraft. Still, it was learned that composite material with poor conductivity is

more likely to be damaged by lightning than aluminum alloy material.

In response to these findings, various protective measures for electronic systems and composite material structures were developed in at the Lightning Technology Company in the United States. They include shielding electrical circuitry, modifying computer software to ensure the capability of resisting electromagnetic interference, as well as applying electrophoretic suppression equipment and so on. So far, most aircraft and parts manufacturers in the world are clients of this company.

Improvement In School Bus Design

Conventionally, chassis of ordinary medium trucks have been as school bus chassis. Nevertheless, as more and more parents demanded that the vehicle provide maximum safety and reliability, manufacturers now started to produce a tailor-built vehicular chassis exclusively for school bus use.



Full-sized aircraft part under test

GLOBAL NAVIGATION SATELLITE POSITIONING SYSTEM:
WORLDWIDE NAVIGATION SYSTEM IN THE FUTURE

Zhuang Huibin

The Global Navigation Satellite Positioning System (GPS) is generally accepted in civil aviation as the foundation for the worldwide outer space traffic control system of the future. Being under construction, GPS is not likely to be placed in general use until next year. To date, 18 GPS satellites are operating in orbit, while the rest will be launched by the end of 1993 as planned. However, the present GPS is mainly applied to military-oriented navigation, hardly considering the demand from aviation and navigation. Therefore, some civilian navigation officials in the United States are eager to see a new navigation system established in 10y, which will satisfy all their needs. Air transport and sea transport groups in the United States have already started working on the next navigation system to be used in the coming century.

The American government made a promise that GPS, once placed in service in 1993, will be accessible to civilian users free of charge for at least 10 years. Construction of GPS system is estimated to take $15-20 billion.

As proposed by the United States, the next GPS will inherit the fundamental technology of the present-day GPS and it is

designated as the Global Navigation Satellite System (GNSS) by the industry. Regardless of the GNSS, international clients can continue using GPS without direct payment up until the next century. Even if payment is needed, the charge per passenger is merely a few score more cents.

Some industry officials agree to use the GPS design as the basic scheme for the future navigation system, viewing GPS as a significant breakthrough made in navigation technology in this century while other people prefer a new design for GNSS. However, the majority believe that with some modifications, the GPS system can meet navigation requirements.

Civil aviation figures show great interest in the ever-growing GPS navigation technology. They claim that compared with other navigation equipment, GPS, which will soon be placed in service, exhibits some superiorities such as it can cover everywhere across the world and also, it can resist the effects of unfavorable factors including weather, electronic interference and the like. Nevertheless, GPS still has two disadvantages: one is when a particular satellite fails, users cannot get immediate notice; the other is there are several "blind regions" in the present GPS coverage, which vary with change of orbits and may therefore endanger aircraft safety. Yet it is reported that the next-generation satellite developed by the International Maritime Satellite Organization--International Maritime Satellite 3 (Inmarsat-3) will carry a navigation system that can overcome the foregoing two disadvantages and can also extend GPS accuracy. This system, adopting the same frequency as GPS satellites, can help GPS users perform accurate positioning even if a blind region appears within GPS coverage. Moreover, a number of experiments prove that when the GPS is fully in place, no blind region will exist within its coverage.

To make it possible for GPS users to receive notice in time

when they lose signal, GPS satellites should be under observation by setting up a large number of observation stations in different parts of the world. Once an observation station discovers any abnormal sign from a particular satellite, it will immediately report to the central station so that users can be informed of the situation without having to utilize the defective satellite.

The navigation system developed by the International Maritime Satellite Organization is applicable to aircraft and warships equipped with Russian Global Navigation Satellite System (GLONASS), which is equivalent to the GPS system.

The global comprehensive observation network used to observe the GPS system requires 16 observation stations, yet even 12 such stations is enough to achieve a desired coverage. Present-day observation systems set up in some countries can be applied to GPS if modified.

Some suggest that an international organization be set up to supervise research and deployment of the navigation system succeeding the GPS, or that some existing institution such as the International Maritime Satellite Organization take the responsibility for coordinating the future GNSS.

The U.S. Federal Aviation Agency (FAA) is currently implementing a 1992-1997 FAA Satellite Navigation Program, which is intended to establish an outer space system for civilian plane navigation, air-to-ground communication and monitoring. According to the agenda of this program, GPS receivers are scheduled to be applied, as a subsidiary navigation tool, to domestic and international flight and non-precision landing navigation in January, 1994.

Both the FAA and the International Civil Aviation Organization believe that the GNSS, including the United States

GPS, Russian Glonass and some other satellite systems, will become the leading navigation system in the 21st century. Marconi, Inc., Canada is currently engaged in developing an aviation-oriented receiver which is a combination of GPS and Glonass. It will not be until late 1998 that GPS receivers will be applied to airfield ground navigation and accurate approach.

As research reports predict, sales of GPS receivers in the global aviation market are expected to reach $500 million by 1996, about 10% of the total gross sales of GPS receivers and much more than the $25 million as anticipated last year. In the United States alone, about 260,000 civilian and military planes are planned to be modified with GPS receivers.

PRESENT SITUATION AND DEVELOPMENTAL TRENDS OF DOMESTIC-BUILT MISSILES IN INDIA

Wu Weiwei

Since the 1980s, India, giving ever-more serious consideration to research and development of domestic-built missiles as a vitally important aspect of high-tech weapon equipment, believes missiles are powerful weapons for the Indian territorial air defense system as well as for resisting external threats. Realizing, following the Gulf War, the position and role that missiles play in modern and future warfare, India apparently speeded up its research and development of home-made missiles and made remarkable achievements. These efforts will undoubtedly favor its guideline of developing missiles on its own, enhance its medium- and long-range strategic and tactical attack capabilities, and influence as well as consolidate its construction of its territorial air defense system.

1. Present Situation of Domestic-built Missiles in India

In 1983, India worked out the "Comprehensive Missile Development Program". After nearly 10 years' research and development, it now possesses six kinds of domestic-built missiles including medium-range ballistic missiles, ground-to air missiles, ground-to-ground missiles, and antitank missiles.

1) Medium-range ballistic missiles

Thus far, India has developed the Agni ("Fire") medium-range ballistic missile which, 19m in length, 14t in weight and 1600-2500km in range, can carry 900km explosive or nuclear warheads. It is equipped with a two-stage rocket engine, fueled with solid and liquid propellants with the SLV-3 engine as its first-stage rocket engine. The Agni missile relies on the strapdown inertial guidance system. The in-missile computer, equipped with a redundant data microprocessor, can in real-time perform interrupts and multiple functions and also, it can be used to conduct missile guidance and flight control, operational prelaunch and postlaunch procedures, as well as check branch systems and telemeter most analog and digital data derived from the missile flight process. According to western military critics, Indian Agni missiles are capable of attacking the entire South Asia region and some other parts of Asia: as far as Iran to the west, Hongkong to the east, China to the north, islands near the equator to the south as well as any place in Pakistan. On May 22, 1989, India successfully launched its first Agni missile. On May 28, 1992, it equally successfully conducted a test with its second Agni missile. Overseas military circles assert that India, possessing the capability of constructing medium- and long-range missiles, has already become the seventh country in the world with its own medium-range ballistic missiles.

2) Ground-to-air tactical missiles

The ground-to-air tactical missiles that India makes are the Trishul missile and the Akash ("Sky") missile.

(1) Trishul Ground-to-Air Missile

This missile, 9-14km in range and Mach2 in speed, can be launched from either ground vehicles or warship, able to

effectively hit low-attitude targets. The double thrust engine of the missile has a case made of high intensity maraging steel, its framework is of an aluminum alloy and its fairing is a fiberglass composite material. From October 1986 to date, this missile has undergone 14 flight tests, based on which its technical parameters have already been finalized. This missile has three models, namely the Army, the Air Force and the Navy versions. According to source information, the Trishul missile can be compared with the Sidewinder missile developed by Thomson-CSF/Matra Inc., France and Excalibur missile made by the Astronautics Company, Britain in performance, but its combat reaction time is even shorter that the foregoing two and furthermore, it can be incorporated with the Akash missile now under development to form a unified air defense system. The Navy version of the Trishul missile is primarily used to deal with missiles such as Flying Fish, Harpoon and the like. The Indian army has ordered this missile, entering mass production in Fiscal Year 1990-1991 and will be widely used by troops in 1993.

Fig. 1. Trishul missile in launch

(2) Akash ("Sky") ground-to-air missile

This missile with a range of 20-35km had its first test flight late in 1988. With a strap-on rocket engine fueled with hypergolic solid propellant, it features low bulk and light weight and, equipped with a phase control array fire control radar, can deal with multiple targets. Currently, India Defense Research and Development Bureau is making efforts to further upgrade this missile system and a new test is expected to start in 1992. It is reported that the Akash ground-to air missile, like the Patriot missile, is a kind of mobile missile, serving as an important component of the ground air defense system in areas of concern. This system consists of a command center and several missile groups. The command center can simultaneously cope with several targets 25-30km away, flying from high-altitude to low altitude 25-30km away before getting into the defense area. This missile is scheduled to be placed in service in 1993.

3) Ground-to-ground tactical missiles

So far, India has the Prithvi ("Earth") ground-to-ground missile which, with a range of 250km, is a ground-to-ground tactical missile, specially designed for the Indian Army. This missile, equipped with a light aluminum alloy body, single-stage double liquid-storage compartment rocket engine, inertial guidance system, and thrust vector control technology, can be launched from ground vehicles, considered as a more advanced model among missiles in its class. It has its first test flight on February 20, 1988, and its fourth test flight on May 5, 1992. As the Indian Defense Research and Development Bureau announced, production of this missile is scheduled in 1993 and to be utilized by Indian Army air defense missile units in 1994.

4) Antitank missiles
(1) Nag ("Snake") antitank missile

The Nag antitank missile, with a range of 3-4km, is based on

an infrared imaging guidance system and is held to be a third-generation antitank missile. With radio instruction guidance, this missile, 13cm in diameter, can penetrate the top armor of all existing tanks.

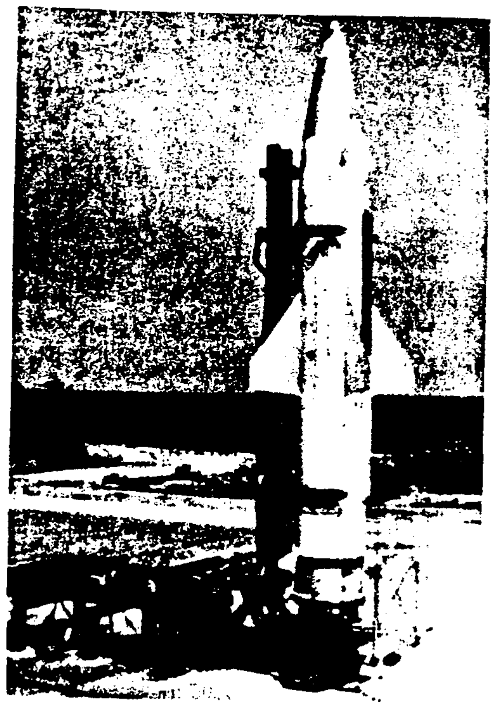


Fig. 2. Indian Prithvi tactical ground-to-ground missile

It is specially designed to attack newly developed armored vehicles including antitank vehicles within 4km. Most strikingly, it can be mounted in tracked vehicles or wheeled vehicles as well as helicopters, which allows rapid deployment in combat areas. Nag missiles will be brought into production in 1994 for the Indian Army. Its air-launched model is also under development and is expected to enter the production phase in 1995 and be used in military operation in 1997.

(2) Kh-dha ("Small Horse") antitank missile

The Khadha missile has undergone three successful test flights. It is an Indian third-generation antitank missile, equipped with an advanced infrared imaging guidance device with 10000 charge-coupled devices. Structurally, the missile is made of carbon fiber and glass fiber material. It is planned to be accessible to deployment in 1993.

Fig. 3. Successful launch of Nag antitank missile

2. Development Trend of Domestic-built Missiles in India

1) Constant increase of funds for and acceleration of domestic-built missile development

Since the implementation of "Comprehensive Missile Development Program" in 1983, more than 9 billion rupees was invested in the development of domestic-built missiles, exceeding the projected total investment of 4 billion by 125%. After the Gulf War, the Indian government has increasingly allocated funds to the development of domestic-built missiles in an effort at speeding up their research and development process. In Fiscal Year 1991-1992, investments by missile companies alone came to 650 million rupees, nearly 12% more compared with Fiscal Year 1990-1991. Other related research institutions also increased their investment by about 10%. A high-ranking Indian official in

charge of missile development disclosed that another more than 2.4 billion rupees was raised for such development as planned in the final stage of "Comprehensive Missile Development Program" and even more additional increases can be possible depending on the situation. Additionally, the Indian government announced that in the nineties, 104.5 billion rupees will be allocated to the vigorous development of space technology related to research and development of medium- and long-range missiles with an ambitious goal of making India a first- class world missile power as a country by the year 2000.

2) Constant strengthening of domestic-built missile development to create a great diversity of missiles

As the Indian Defense Research and Development Department claims, domestic-built missiles have made remarkable progress but suffer from a lack of innovation because of the absence of series-built products and therefore, one direction in developing domestic-built missiles is to amplify missile systems and diversify missiles by increasing their types. To achieve this goal, India is developing or is planning to develop air-to-air missiles, air-to-ground missiles, antiship missiles, subsonic cruise missiles, and intercontinental ballistic missiles. For instance, the Astra air-to-air missile developed by India has passed a technical feasibility demonstration and is scheduled to undergo a test flight soon. If this project is implemented, it will certainly promote the development of India domestic-built missile technology. As planned, Astra will be put into production and use after 1995. In addition, India is developing the SS45 tactical air-to-air missile which, with a range of 40-50km, is supposed to replace the BM-21 missile system built by the former Soviet Union. It was learned that the successful development of Prithvi will vigorously facilitate the development of the SS45 missile system, This missile will be ready for production after 1996. At the same time, India is also

developing the most advanced antitank missile--the Hathi ("Elephant"), which, with a range of 3-4km, high strike accuracy, and high mobility, fits well into antitank operations. Most remarkably, India will develop subsonic cruise missiles and intercontinental ballistic missiles. The Indian government has repeatedly announced that India has already reached the capability of developing cruise missiles and intercontinental ballistic missiles. The successful launch of the Agni medium-range ballistic missile suggests that India already possesses both the technology and capability necessary for producing the foregoing two kinds of missiles. If needed, India will build cruise missiles and intercontinental missiles. Indian defense scientists maintain that they can build one intercontinental ballistic missile any time as long as the government provides funding and issues orders. Recently, Indian military circles urged approval from the government for producing cruise missiles and intercontinental ballistic missiles, which will accelerate the progress in building the foregoing two kinds of missiles. Within 1992, India will also launch missiles over 3000km for the third time. It appears that India already has the ability to launch intercontinental ballistic missiles with a range of more than 9000km.

3) Active importation and development of new technologies and the enhancement of high-tech domestic-built satellites

India realizes that its domestic-built satellite technology needs improvement and modification. As Aronochalam, the Indian "father of missileS" said, there are many technical elements related to Indian domestic-built satellites that are expected to be improved and upgraded; some of them can be developed on our own, yet the rest should be achieved through importation and conversion of overseas advanced technologies. India has thus imported from France the Flying Fish antiship missile technology, the MILAN antitank missile technology, the Magic and Super-530

air-to-air missile technology to help construct its first domestic-built antiship missile and air-to-air missile in a short period of time. Regardless of heavy pressure from the United States, India purchased from Russia the high-tech required in launching ballistic missiles so as to push the development of domestic-built medium-range ballistic missiles. Along with importing and converting technologies, Indian defense scientists are developing some new technologies on their own, which can hopefully be applied to their domestic-built satellites as soon as possible. These new technologies include: the HTPB propulsion agent, similar to that adopted in the American Patriot missile; the B-HMX hypergolic fuel; the compound booster, the focal plane array(FPA)sensor, the W-frequency automatic tracker, and the W-frequency 10-W silicon IMPATT diode--for missile launches as well as phase shifters used for three-dimensional radar phase control array of ground-to-air missile systems. Naturally, with the development and application of these new technologies, the high-tech status of India's domestic-built missiles will be significantly increased.

SEVERAL MISSILE SYSTEMS BUILT BY THE FORMER SOVIET UNION DISPLAYED IN MOSCOW AIR SHOW

He Xin

In August 1992, several kinds of missiles built by the former Soviet Union were displayed at the Moscow Air Show. Following is a detailed introduction to these missiles.

1. Ground-to-Air Missiles

The ground-to-air missiles displayed in the show include the SA-4, SA-6, SA-10_a, SA-11, SA-12, SA-13, SA-15, as well as the 2S6 artillery missile air defense weapon system.

In fact, the SA-11 is merely a replacement of SA-4 and SA-6. According to reports, it was not until the late seventies that this kind of missile was brought into service, and later it was widely deployed in the eighties.

The SA-11 air defense missile system mainly includes command station, target-search radar, transporter-erector-launcher, loading launch arrangement, and missiles. The transporter-erector-launcher is mounted on a tracked armored truck bed, which can resist not only small arms fire, but can also survive attack from nuclear, biological, and chemical weapons while tightly sealed.

Its maximum design road speed is 65kmh; its maximum range is 500km. The range of the target-search radar varies with target height, with a maximum of 100km. It is said that the target-search radar shows a strong capability in resisting jamming and can get into operation as quickly as within 5min after the vehicle stops, and at the same time, can send data to its command station through a data link and a ground communication link.

The command station can, at the same time, automatically track up to 15 out of 75 targets detected by the search radar, and then distribute them to the transporter-erector-launcher to commence an attack. Usually, each command station can control six transporter-erector-launchers, and each such equipment carries four missiles positioned horizontally when on the road, and erected before being launched.

The radar is installed in front of the launcher and can lock on a target as far away as 70km away (3000m in height). For low-altitude targets, the lock-on distance is rather shorter.

Ordinarily, each transporter-erector-launcher has its own target to hit, usually, two missiles per target.

The launcher (see Cover 3) basically is similar to the transporter-erector-launchers, except it has no radar mounted in front. This vehicle carries four missiles ready to be launched and four reserve missiles that can be transferred to the transporter-erector-launchers on special means provided on the vehicle. Additionally, it can launch missiles directly from the loading truck in the event that the transporter-erector-launcher provides it with target information and target illumination.

The SA-11 missile is 5.5mm in length, 690kg in launch weight, and has a 70kg high-explosive warhead. Depending on the type of target, its effective operational height can reach 22km

and firing range--32km.

Other auxiliary facilities include automatic test setting, maintenance truck, and missile supply carrier. The carrier can be loaded with six missiles with packing containers, and eight missiles without packing containers.

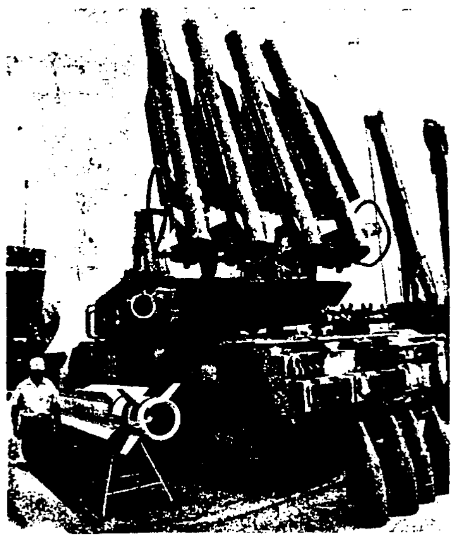


Fig. 1. The SA-11 is one of the most advanced ground-to-air weapons in the former Soviet Union

The ship-to-air missiles displayed in the Moscow Air Show were as follows: the SA-N-1, SA-N-3, SA-N-6, SA-N-7, and SA-N-9.

The SA-N-7 is a shipborne version of the SA-11, which is designed to equip 1500-ton surface warships, with a 360° radar system. Under its single-track launch pad there is an ammunition chamber containing 24 missiles. With eight launch patterns, it can meet the needs of different military operations. Its basic system includes a single launch pad, with 24 missiles and two tubes; the complex system based on large warships, with 96 missiles and 12 tubes, is designed to deal with continuous air attacks.

The SA-N-7 is equipped with a solid-fuel rocket engine, whose maximum speed can reach Mach3. Its launch section can be ignited through radio fuzing, and its launch weight and launch section weight are the same as for the SA-11. It can attack aircraft 15 to 15000m in height and 18 to 25km away and can also hit attacking air-to-ground missiles at a height of 10 to 10,000m and 3.5 to 12km away.

With a slight modification, the SA-11 missile can be mounted on existing warships. The fire control system of this missile can also control naval air defense guns. The standard facilities include built-in test equipment and a launch simulator for training use.

The SA-N-6 is the shipborne version of the SA-10, which was placed in service on some large surface vessels such as the cruiser Gilov. This system has the capability of launching at most 12 missiles at one time to attack six air targets, with two missiles per target.

The SA-N-6 adopts a vertical launch pattern, with missiles similar to those in the SA-10 system. The SA-10 utilizes three kinds of missiles, namely the 5v55k missile with a range of 45km, the 5v55R missile with a range of 75km, and a new missile type with a range of 90km. Missiles are stored in tightly sealed launch tubes with 10 years' reserve period. Below every area of the deck, there is a rotary launch pad, storing 48 or 64 missiles. Its multifunctional radar exhibits good jamming resistance. Its range can be as much as 90km when a target is located at a height of 2000m or over 2000m, while the range is 25km when the target is 20m or below 20m in height.

The SA-N-9 is the shipborne version of the SA-15, launching the same kind of missiles as the SA-15. It adopts a vertical launch pattern and is capable of attacking a fast-moving target

moving at 2500kmh, with a maximum range of 12km depending on target type.

The SA-N-9 is an all-weather system and can attack warplanes, missiles, and remote-piloted vehicles. Its fire control system can also be used to control the 30mm short-range weapon system. Generally speaking, the SA-N-9 system can simultaneously launch as many as eight guided missiles to attack four targets, with two missiles per target. The missile has a launch weight and air explosion warhead, respectively, of 165kg and 15 kg.

2. Air-to-Air Missiles

The AAM-AE air-to-air missile made in Russia is equivalent to the Advanced Medium-Range Air-to-Air Missile (AMRAAM) in western countries. With a launch weight of 175kg, it can attack a mobile target with 12g overload. As a result, it can be used against warplanes, cruisers, ground-to-air missiles as well as air-to-air missiles. The AAM-AE missile, mounted with a radar seeker, is a omnidirectional, all-weather weapon, which, while launched, can operate against any weapon even in the presence of jamming.

This missile is fitted with four long and thin cruciform wings in the centroid-rear section and four grid-shaped tail fins in the missile rear. It can strike fixed targets at a maximum height of over 80km. Additionally, it is said that enhancement of its missile range can be achieved by expanding the solid-fuel engine. The AAM-AE missile can be used, after its range is increased, to deal with early-warning aircraft at a maximum range of 150km.

In addition, the AAM-AE can be equipped with an infrared seeker to lock on targets in flight. The basic AAM-AE model that

is mass production is 3.6m in length and 0.2m in diameter. With such small diameter, it is difficult for the enemy to detect and intercept the AAM-AE. Yet the radar cross section must become larger owing to the grid-shaped tailplane.

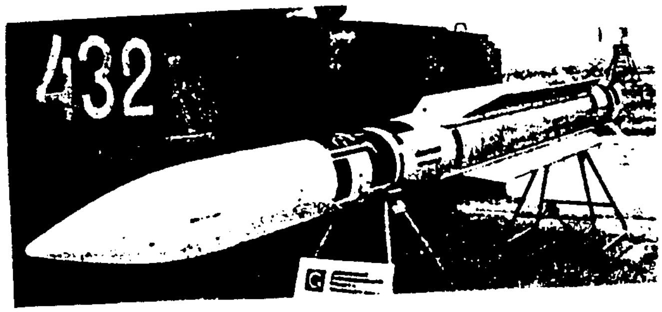


Fig. 2. SA-11 missile

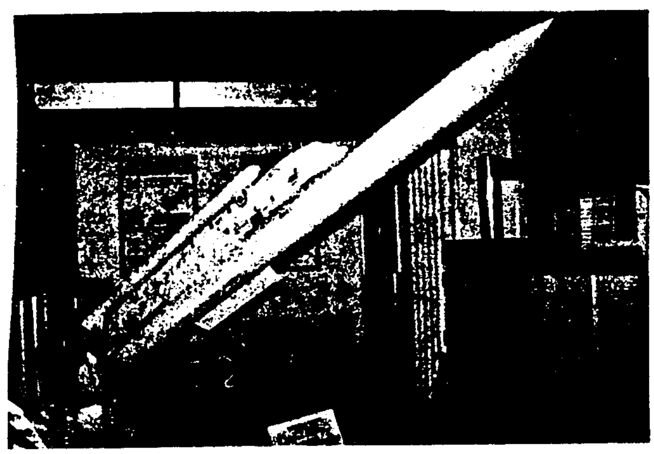


Fig. 3. AAM-AE air-to-air missile

3. Air-to-Ground Missiles

The Kh-31A all-weather antiship missile is a modification of the Kh-31 anti-radiation missile, which can be used not only to cripple a ground-based radar system, but also can also attack air warning and monitoring aircraft.

Equipped with an active radar seeker, the Kh-31A can be applied as a launched weapon outside the area under defense to attack a warship with 8000t displacement.

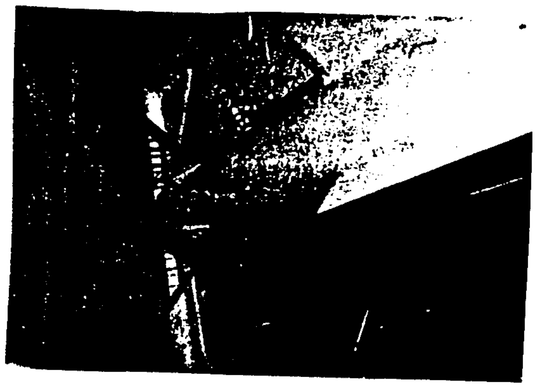


Fig. 4. Grid-shaped tailplane of AAM-AE air-to-air missile

The Kh-31A has a configuration similar to the Kh-31 and utilizes the same rocket-stamped body engine. The maximum speed of the Kh-31 and Kh-31A is up to 1000m/s, and the weight of the warhead is 90kg, the launch weight is 650kg, which is 50kg heavier than that Kh-31. Additionally, the Kh-31A has a range of 5 to 70km and can be launched by missile carrier to a height of 50 to 15000m.

The Kh-35 antiship tactical missile (see Cover 3) is in the same class as the U.S. Harpoon missile. Sources reported that its range is designed to be above 130km, with 600kg launch weight, 145kg warhead, and maximum speed upwards of 300m/s. Still, its tail/missile wings are folded before launch.

Among other matters, on display in the show was a new type of aircraft (see Cover 3) made by the ENICS Company, Russia, which has a pulse air-jet engine and can be dropped in air. The E85 system has a launch weight of 120kg, a speed of 70-166m/s, an

estimate range of 70km, and an operational height of 200-3000m.

According to a report, since it was formed in 1988, ENICS Company has developed a series of straight and U-shaped pulse air-jet engine, whose thrusts are respectively 10, 30, 50, 100, 250 and 400newtons, with an annual production of 500.

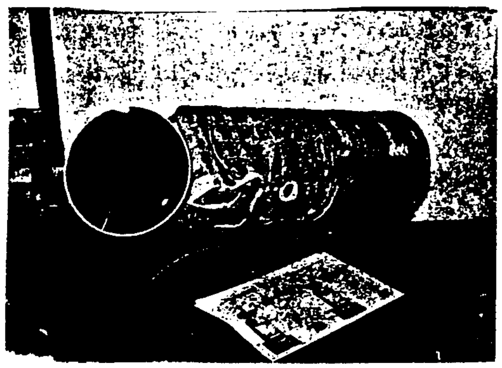


Fig. 5. Multifunctional monopulse active radar seeker designed to be used on the new missile, or the R-27

During the show, another new multifunctional monopulse doppler active radar seeker was exhibited, which has gone through its design phase and is about to enter its development phase. This kind of seeker is tailor-built for the new type of missile or the R-27 (AA-10, Alamo) air-to-air missile.

With such active seeker, the R-27 missile can be used to attack a target with a $5m^2$ radar cross section within a range of 70km. Also, if equipped with the same fire control system as in MiG-29, the R-27 missile can perform a mid-phase adjustment within 50km before the seeker locks onto target within the last 20km. The seeker is provided with an inertial system and searches for targets with an active radar in the terminal-flight phase, and it can receive target-distributing commands from the

aircraft fire control system after 2min preheating. Then it can be ready for launch within 1.5s following a target adjustment. Generally, without fairing, this seeker is 14,5kg in weight, 600mm in length, and 200mm in diameter.

CONTINUOUS DEPLOYMENT OF GLONASS SATELLITE SYSTEM IN RUSSIA
Li Hueiting

Russia has openly expressed that the view that the Global Navigation Satellite System (Glonass) will be continuously deployed. However, the plan of placing this system into full operation in 1995 is likely to be delayed till 1996 or 1997.

The adoption of the Glonass system by international civil aviation is based on geopolitical and technical concerns. Since the Global Positioning System (hereinafter referred to as GPS) is owned and operated by the United States Air Defense Agency, some countries have expressed their concern over the prospects of international civil aviation relying on the GPS. The adoption of Glonass can relieve this worry even though it is under the control by Russian Air Defense Agency.

The GPS and the Glonass systems both have 24 satellites. Thus, even if there is a sudden fault with one or two satellites, navigation accuracy may not be affected, which is genuinely important to the application of the Glonass system as accurate equipment for instrument approaches and landings.

In the past, due to technical problems and the breakup of the former Soviet Union, Glonass ground to a halt. Nevertheless, the Russian Ministry of Defense reportedly decided to assure the required funding for this program on August 10, 1992. Meanwhile, 11 Glonass satellites have brought into operation. Three satellites launched on July 5, 1992 are to be placed in service as well.

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE
B085 DIA/RTS-2FI	1
C509 BALLOC509 BALLISTIC RES LAB	1
C510 R&T LABS/AVEADCOM	1
C513 ARRADCOM	1
C535 AVRADCOM/TSARCOM	1
C539 TRASANA	1
Q592 FSTC	4
Q619 MSIC REDSTONE	1
Q008 NTIC	1
Q043 AFMIC-IS	1
E404 AEDC/DOF	1
E410 AFDTC/IN	1
E429 SD/IND	1
P005 DOE/ISA/DDI	1
1051 AFIT/LDE	1
PO90 NSA/CDB	1

Microfiche Nbr: FTD96C000292
NAIC-ID(RS)T-0106-96